Dynamic Decision Networks:
Applications for the Future Combat System

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Three year period of performance

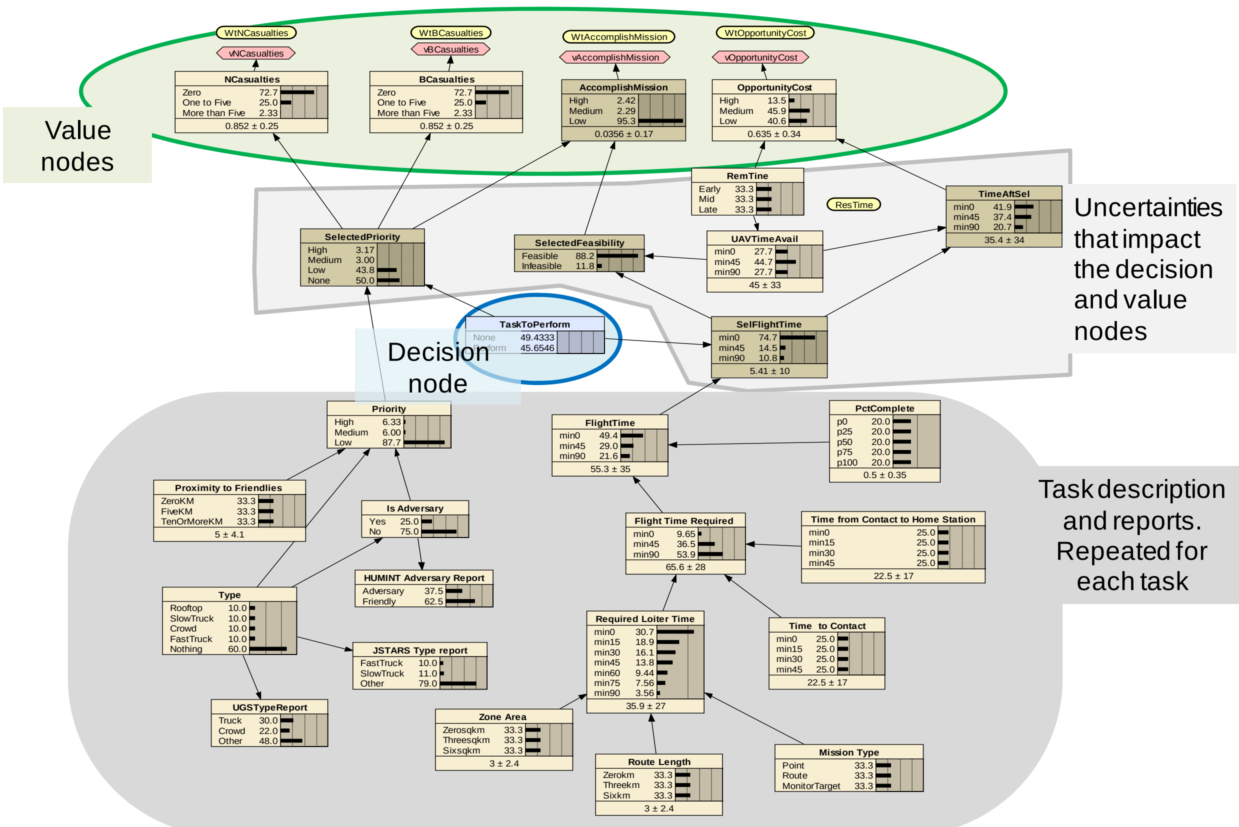
A Dynamic Decision Network (DDN) is a combination of an influence diagram and a Bayesian network that addresses problems with the following characteristics:

- The environment for making the decision is dynamically changing.
- Significant amounts of information are available to the decision maker in the form of human reports and sensor reports
- New alternatives arise at unexpectedly times. Some alternatives disappear either by previous actions taken by the decision maker or by known or unknown causes.
- The decision maker is either prompted for decision choices at specific times (some known and some not known) or the decision maker must select points in time to make decisions
- The decision addresses the timing of a choice as well as what choice to make at each time
- These decisions are best characterized as operational choices associated with achieving some mission or successfully completing a task.
    - Should I engage a target of opportunity now or wait till later? If so, which one?
    - Should I use resource A, B, C or none to do a specific task?
    - Should I release a new product now? If so, how should the new product be released?
- The decision must address the advantages of waiting to select a specific choice at a later time when better information about the situation may become available and scarce resources are being conserved. The advantage of selecting a choice now is that the opportunity to utilize the scarce resource may deteriorate based on natural causes or the actions of an intelligent adversary, reducing the chances of the achievement of the overall operational mission.

The DDN decision support approach must:

1. Modify the decision alternatives over time as new opportunities arise and old opportunities disappear, possibly because of actions taken in previous decisions.
2. Balance multiple conflicting objectives based on preferences provided by the decision maker.
3. Provide feedback to the decision maker concerning sensitivity of recommended decision to these preferences
4. Define the uncertainty associated with the situation using some rigorous approach to uncertainty
5. Maintain the definition of uncertainty over time as new information is obtained in a way that is consistent with previous representations of uncertainty
6. Integrate sensor and source reports (from imperfect sensors and sources) into the description of the uncertainty about the situation
7. Incorporate any risk preference of the decision maker that properly address the situation
8. Include decision options about how best to configure the sensors available to the decision maker during future time periods in terms of locations sensed and sensor mode. These recommended choices for the sensor decisions should be consistent with the current uncertainty associated with the situation.
9. Incorporate the scarcity of resources available to the decision maker.

Our effort developed over 20 DDN models for a variety of Army unmanned vehicles, unattended sensors, and manned activities (e.g., non-line of sight fire control, dismounting from an armored vehicle) associated with the Army's Future Combat System. Our research demonstrated that these models could integrate up to 20 different sensor inputs nearly instantaneously to produce a decision recommendation that addressed multiple conflicting objectives. These recommendations were produced dynamically as the situation changed and new alternative courses of action became available or existing ones disappeared.



In addition, we developed three software architectures for implementing DDN applications within a simulated environment. The first software architecture was a C++ wrapper around Netica (a commercial software tool for influence diagrams and Bayesian networks). The second software architecture linked the first software architecture to Cougaar (an AI blackboard architecture) via Java communications. The third software architecture connected the first year's approach to Extend (a commercial tool for discrete event simulation with a visualization environment) via Excel.

This DDN concept can now be easily tailored to nearly any dynamic decision making environment.